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CORNELL UNIVERSITY

Center for Radiophysics and Space Research

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FINAL TECHNICAL REPORT

for

NASA Grant NSG-2412

Molecular Spectroscopy from the Kuiper Airborne Observatory

October 1, 1979 to December 31, 1984

Principal Investigator: Prof. Steven Beckwith

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This grant covered a broad research program aimed at investigating interstellar and circumstellar molecules through medium-resolution infrared spectroscopy of the vibration-rotation and pure rotational transitions. A primary goal was the construction and improvement of instrumentation for the near and middle infrared regions, wavelengths between 2 and 10 microns. The main instrument was a cooled grating spectrometer with an interchangeable detector focal plane which could be used on the Kuiper Ariborne Observatory (KAO) for airborne observations, and also at ground-based facilities such as NASA's Infrared Telescope Facility (IRTF). The relatively broad wavelength coverage, moderate resolution ($\lambda/\Delta\lambda \sim 1000$), sensitivity (instrumental NEP's between 10^{-15} and 10^{-13} W $Hz^{-1/2}$, depending on wavelength), and portability made it possible to address several current problems in astrophysics, including one purely theoretical study stimulated by the observations (Beckwith, Natta, and Salpeter 1983).

Investigations of interstellar shock waves included studies of H_2 emission from the Orion Nebula (Beck and Beckwith 1983, Beckwith 1982, Beckwith et al. 1983), W51 (Beckwith and Zuckerman 1982), and the proto-planetary nebulae CRL 2688 and CRL 618 (Beckwith, Beck, and Gatley 1984). The observations determined the physical conditions in shocked molecular gas near these objects. From these it was possible to characterize the energetic history of mass loss from both pre- and post-main sequence stars in the regions. It is evident that extensive mass loss is a common feature of stars not on the main sequence. A major review article (Shull and Beckwith 1982) resulted from this work. Spectra of both old and young objects, including planetary nebulae (Beckwith et al. 1984, Russell et al. 1982) and molecular clouds (Evans et al. 1984),

reproduced the well-known unidentified infrared features discovered by several years ago using the KAO. The features were heavily overresolved in the recent spectra, but no evidence for substructure appeared. This confirms the belief that these features result from solid-state resonances in interstellar dust, presumably in surface coatings on the grains. Tentative identifications of new molecular features were found in spectra of the evolved star U Ori (Beckl et al. 1985), but the features are extremely weak, and the identifications are uncertain. It appears that higher spectral resolution (an order of magnitude or more) will be required to extensively study molecular features in circumstellar and interstellar material.

Accurate measurements of the KAO mirror emissivity were made for the first time with this spectrometer. A detailed report (Beckwith and Skrutskie 1984) is available from Ames Research Center.

Partial support was used for a variety of smaller efforts. These include studies of infrared lines in galactic nuclei (Beck and Beckwith 1984; Beck, Beckwith, and Gatley 1984), faint photometry of galaxy halos and intergalactic gas (Skrutskie, Shure, and Beckwith 1984; Skrutskie, Shure, and Beckwith 1985), speckle interferometry of young (Beckwith et al. 1984) and evolved (Dyck, Beckwith, and Zuckerman 1983) stars, and studies of the interstellar extinction law through spectra of the region in Mon R2 (Natta et al. 1985).

A complete bibliography appears in Appendix A. One post-doctoral research associate (S. C. Beck), one graduate student (M. F. Skrutskie), and a full-time technical support specialist (J. Wyant) were supported by this grant.

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